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RESEARCH MEMORANDUM

EFFECT OF A FUSELAGE ON THE LOW-SPEED LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A 45° SWEPTBACK WING WITH DOUBLE SLOTTED FLAPS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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EFFECT OF A FUSELAGE ON THE LOW-SPEED LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A 45° SWEPTBACK WING WITH DOUBLE SLOTTED FLAPS

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SUMMARY

A low-speed investigation has been made to determine the effect of a fuselage on the longitudinal aerodynamic characteristics of a 45° sweptback wing equipped with 0.35-semispan double slotted flaps. The wing had an aspect ratio of 3.7, a taper ratio of 0.41, and a streamwise thickness ratio of 0.086. The cylindrical fuselage had an ogival nose and a ratio of diameter to wing span of 0.12. The double slotted flaps consisted of a 0.213-wing-chord main flap and either a 0.500-flap-chord vane or a 0.266-flap-chord vane. An extended plain flap was simulated by blocking the slots in the double slotted flap.

The fuselage had a favorable effect on the lift characteristics of the double slotted flap. However, the presence of the fuselage had an adverse effect on the lift characteristics of an extended plain flap.

The double slotted flaps increased the lift with an increase in flap deflection up to a flap deflection of 80.4° for a flap which had a ratio of vane chord to flap chord of 0.500, and up to 60.8° for the flap with a smaller vane. At these deflections and at an angle of attack of 0°, a lift-coefficient increment of 0.73 was produced by the flap and large vane, and a lift-coefficient increment of 0.59 was produced by the flap and small vane. Maximum lift coefficient for the configuration was 1.23, obtained with the flap and large vane at an angle of attack of about 11°, and 1.14 for the flap and small vane at an angle of attack of about 12°. The fuselage had a favorable effect on the drag characteristics of the double slotted flap at high lift coefficients and had little effect on the pitching-moment characteristics.

For the double slotted flaps deflected about 60°, increasing Reynolds numbers from 0.93×10^6 to 3.35×10^6 had no appreciable effect on the lift characteristics. At moderate lift coefficients, increase in Reynolds number had some slight favorable effects on the drag and pitching-moment characteristics.

INTRODUCTION

A wind-tunnel investigation is being made by the National Advisory Committee for Aeronautics to study the characteristics of various high-lift devices on a full-scale 45° sweptback wing. Reference 1 presents the results of tests on a 1/5-scale model equipped with the double-slotted-flap designs proposed for full-scale testing. These tests were on a wing alone, however, and the effects of the presence of a fuselage on the flap-effectiveness characteristics may be large. Therefore, the present investigation was undertaken to determine the longitudinal aerodynamic characteristics of the wing used in reference 1 with a fuselage added. The results of the present investigation are compared with the results of reference 1 to show the fuselage effects.

The investigation was made in the Langley 300 MPH 7- by 10-foot tunnel. The wing investigated had an aspect ratio of 3.7, a taper ratio of 0.41, and an average thickness ratio in a streamwise direction of 0.086. The fuselage was cylindrical and had an ogival nose. The effect of fuselage proximity on the flap characteristics was studied by simulating the fuselage with a large movable plate. The 0.35-semispan, inboard, double slotted flaps consisted of a 0.213-wing-chord main flap and either a 0.500-flap-chord vane or a 0.266-flap-chord vane. An extended plain flap was simulated by blocking the slots in the double slotted flap with 0.500-flap-chord vane. In addition, some tests were made with the flap span extended inboard to the fuselage.

The general investigation was made at a Reynolds number of 1.8×10^{6}. Tests of the double slotted flaps were made over a Reynolds number range of 0.9×10^{6} to 3.4×10^{6} with the flaps deflected about 60°.

SYMBOLS

The forces and moments measured on the wing are presented about the wind axes which, for the conditions of these tests (zero sideslip), correspond to the stability axes. The pitching-moment data are measured about the origin of axes, as shown in figure 1, which corresponds to the 25-percent-chord station of the mean aerodynamic chord. The lift, drag, and pitching-moment data presented herein represent the aerodynamic effects of deflection of the flaps in the same direction on both semispans of the complete wing.

C_L lift coefficient, F_L/qS

ΔC_L increment of lift coefficient

C_D drag coefficient, F_D/qS

$C_{m,w}$ pitching-moment coefficient, $M_{Y_W}/qS\bar{c}$

F_L twice lift force of semispan model, lb

F_D twice drag force of semispan model, lb

M_{Y_W} twice pitching moment of semispan model measured about $0.25\bar{c}$, ft-lb

q free-stream dynamic pressure, $\rho V^2/2$, lb/sq ft

S twice wing area of semispan model, sq ft

$\bar{c}$ mean aerodynamic chord of wing, ft

c local chord, ft

b wing span, ft

V free-stream velocity, ft/sec

ρ mass density of air, slugs/cu ft

α angle of attack of wing, deg

d/R ratio of distance of plate from plane of symmetry to fuselage radius

δ_f flap deflection relative to wing chord plane, measured in a plane normal to a line swept back 36.77° (positive when trailing edge is down), deg (fig. 2)

Subscripts:

f flap

Λ normal to a line swept back 36.77°

MODEL AND APPARATUS

A drawing of the model is given in figure 1. The wing was of aspect ratio 3.7 and taper ratio 0.41 and had symmetrical airfoil sections. Leading-edge sweep was 47.8° and the wing had no geometric dihedral or twist. The thickness ratio of the wing section in a streamwise direction varied from 0.083 at the root to 0.090 at the tip. The test wing was a 1/5-scale model of a wing on which a full-scale wind-tunnel investigation of high-lift devices is in progress. The model wing was derived in the same manner as the full-scale wing in that the sweep of an existing wing was increased and the plan form was further altered by reducing the sweep of the wing trailing edge and fairing the sections to the revised trailing edge with straight lines. The resulting airfoil sections at the two spanwise stations shown in figure 1 are given in table I.

The direction in which the flap ends were cut, the forward limit of space available for retraction of the flap (0.735-wing-chord line), and the span of flap (0.160b/2 to 0.507b/2) were determined by the structure of the full-scale wing. Detailed dimensions of the flaps and vanes are given in figure 2 in the plane of the flap ends and coordinates of the flap ends are given in table II. However, numerical reference throughout the present paper is made to the streamwise chords of the flap and vanes. The double-slotted-flap arrangement consisted of a 0.213c main flap in combination with a $0.500c_f$ vane and also with a $0.266c_f$ vane (streamwise values). Both of these configurations were capable of being retracted into the designated space in the wing. The $0.500c_f$ vane was chosen because it was shown to be the optimum in a summary of two-dimensional results (ref. 2). The $0.266c_f$ vane was the largest vane which could be retracted into the designated space in the wing without relative movement between vane and flap. St. Cyr 156 airfoil sections (ref. 3) were used for the vanes because the rounded leading edge of the section allows deflection of the vane-flap assembly as a unit about a fixed pivot through a large angle range while maintaining a desirable lip and vane relationship (fig. 2); in addition, the sections remain unstalled over a large range of angle of attack. The flap-deflection angles were measured in the plane of the flap ends; that is, normal to a line swept 36.77°.

Filler blocks of balsa wood were provided to block the slots in the flap with $0.500c_f$ vane when an extended plain flap is simulated (fig. 2(a)).

The fuselage (fig. 1) was a cylinder with an ogival nose and a ratio of diameter to wing span of 0.12. A large aluminum plate (fig. 3) was used to approximate the effect of the proximity of the fuselage to the inboard end of the blocked flap. The plate was adjustable over the part of the span of the wing inboard of the flap. The model with the flap span extended inboard to the fuselage is shown in figure 4. This extension, which was made of sheet metal and had no slots, was used for some tests with the double slotted flap and with the blocked flap.

The unmodified wing was solid aluminum. The trailing-edge modification described herein and the flap were made of mahogany reinforced with an aluminum plate extending to the trailing edge of the wing. The fuselage was constructed of laminated mahogany. Both vanes were machined from aluminum. The larger of the two vanes was supported at each end, but the smaller vane required a center support in addition to the end supports.

The semispan model was mounted vertically in the Langley 300 MPH 7- by 10-foot tunnel. The root chord of the model was adjacent to the ceiling of the tunnel, which served as a reflection plane. A small clearance was maintained between the model and the tunnel ceiling so that no part of the model came into contact with the tunnel structure. The fuselage minimized the effect of spanwise air flow over the model through this clearance hole. For tests with the fuselage removed, the effect of spanwise air flow was minimized by a 1/16-inch-thick end plate which projected about 1 inch above the wing surface at the root of the wing.

TESTS AND CORRECTIONS

Description of Tests

All tests were made in the Langley 300 MPH 7- by 10-foot tunnel. Data were obtained through an angle-of-attack range of -6° to 26° for all configurations. The flap-deflection range for the double-slotted-flap tests was approximately 41° to 90° for the flap and $0.500c_f$ vane and 41° to 71° for the flap and $0.266c_f$ vane.

The tests in general were performed at an average dynamic pressure of 25.4 pounds per square foot, which corresponds to a Mach number of 0.13 and a Reynolds number of 1.8×10^{6} based on the mean aerodynamic chord of the wing. Tests over a range of Reynolds numbers were made with both double-slotted-flap designs at a flap deflection of about 60°. The Reynolds number was changed by raising the tunnel velocity from 45 miles per hour to about 200 miles per hour. Mach number effects in this speed range are considered negligible. The conditions for the variable Reynolds number tests are given in the following table:

Dynamic pressure, lb/sq ft	Mach number	Reynolds number
6.9	0.06	0.93×10^6
25.4	.13	1.83
65.5	.21	2.86
91.8	.25	3.35

In addition to the tests of the double-slotted-flap configurations, tests of the flap and $0.500c_f$ vane were made with both slots blocked. Tests in which the large movable plate (fig. 3) was used to simulate the proximity of a fuselage to the inboard end of the flap with slots blocked were made at a flap deflection of about 60°.

Tests with the flap extended spanwise to the fuselage (fig. 4) were made at flap deflections of 70.7° with the double slotted flap and at 50.7° and 70.7° with the slots blocked.

Corrections

Jet-boundary corrections, determined by the method presented in reference 4, have been applied to the angle-of-attack and to the drag-coefficient values. Blocking corrections, to account for the constriction effects of the model and its wake, have also been applied to the test data by the method of reference 5.

RESULTS AND DISCUSSION

Presentation of Results

The basic longitudinal characteristics are presented for the wing-fuselage model with double slotted flaps in figure 5 and for the model with extended plain flaps in figure 6. The effects of the fuselage on the aerodynamic characteristics were obtained by comparison of the present data with the wing data of reference 1. Comparisons showing the effects of the fuselage on the aerodynamic characteristics of the plain wing in pitch are presented in figure 7, and on the variation of ΔC_L with δ_f for the wing with double slotted flaps and with blocked flaps, in figures 8 and 9, respectively.

The results of tests to determine the effect of extending the span of the flaps inboard to the fuselage are given in figure 10 and are compared with the basic flap-effectiveness characteristics in figure 11.

The characteristics of the flapped wing with a large plate used to simulate the effect of fuselage proximity are shown in figures 12 and 13. The results of tests of the wing-fuselage model at several Reynolds numbers and with the double slotted flap deflected 60° are presented in figure 14, and the variation of incremental lift coefficient with Reynolds number is shown in figure 15 for $\alpha = 0^{\circ}$.

Lift Characteristics

Wing-fuselage model.- Basic wing-fuselage results at $\delta_f = 0^{\circ}$ (fig. 5) show a lift-curve slope of 0.055 and a maximum lift coefficient of 1.03 at an angle of attack of 23°.

Model with double slotted flaps.- The results for the model with double slotted flaps and with the large vane (fig. 5(a)) show that a large lift-coefficient increment was obtained at $\alpha = 0^{\circ}$ by deflecting the flaps. However, the stall of the flapped wing (at $\alpha \approx 11^{\circ}$) occurred at a much lower angle than the model with $\delta_f = 0^{\circ}$ $(\alpha \approx 23^{\circ})$. Therefore, the resulting maximum lift coefficient for the flapped configuration was only about 0.2 greater than the maximum lift coefficient of 1.03 attained with $\delta_f = 0^{\circ}$. The maximum lift coefficient for the double slotted flaps with the small vane was 1.14 at $\delta_f = 60.8^{\circ}$, as is shown in figure 5(b).

The results (also see fig. 8) indicate that increasing the vane size resulted in greater ΔC_L over the angle-of-attack and deflection range. At $\alpha = 0^{\circ}$, the maximum ΔC_L was 0.73 at $\delta_f = 80.4^{\circ}$ for the double slotted flap and large vane compared with 0.59 at $\delta_f = 60.8^{\circ}$ for the flap and small vane. The loss in lift increment was very abrupt for either flap and vane combination at deflections above the deflections for maximum ΔC_L. The higher effectiveness of the flap and large vane is mainly the result of the ability of the vane to control the flow over the flap to higher deflection angles and to a lesser degree, its greater area.

Model with slots blocked.- For comparison with the double slotted flap, the characteristics of an extended plain flap were obtained. The extended plain flap was simulated by blocking both slots of the double slotted flap as shown in figure 2(a) and will be referred to as the blocked flap. The results (fig. 6) show a similar variation of lift coefficient with angle of attack at $\delta_f = 40.7^{\circ}$ for the blocked flap and for the double slotted flap. At the higher flap deflections tested, the lift curves for the blocked flap are nonlinear and the increase in lift increment gained by deflecting the flaps to 50.7° and higher is very small, especially in the range of angle of attack from 2° to 7°.

Comparison of figures 5 and 6 shows that the result of blocking the slots was a considerably lower value of ΔC_L for flap deflection above 40.7°. This result is also shown in figure 11.

Effect of the fuselage.- Plain-wing results of reference 1 are compared with wing-fuselage-model results in figure 7. Adding the fuselage to the wing increased the lift-curve slope from 0.053 to 0.055 at low angles of attack and increased maximum lift slightly.

The effect of the fuselage on the lift of the wing with flaps deflected was considerably greater as shown in figure 8. Adding the fuselage to the wing with double slotted flaps increased ΔC_L by an average of 0.06 over the deflection range at $\alpha = 0^{\circ}$ and somewhat less at $\alpha = 10^{\circ}$. Maximum lift coefficient of the wing-fuselage model with double slotted flaps and $0.500c_f$ vane was 1.23 as compared with the value 1.17 given in reference 1 for the configuration without a fuselage. When the slots were blocked (see fig. 9) the fuselage effects reduced the lift increment at flap deflections greater than 40.7°. In reference 1, in fuselage-off tests, the existence of a vortex-type flow over the inboard end of the flap was given as a possible explanation of the ability of the flap with slots blocked to maintain effectiveness to high flap-deflection angles $\left(\delta_f = 70^{\circ}\right)$. Observation of the flow by means of a tuft on a probe indicated that a vortex did not form after the fuselage was added and, therefore, the flap was not effective at the higher angles.

A further change in the conditions at the inboard end of the flap was made by extending the span of the flap inboard to intersect the fuselage. The results of the tests of the double slotted flap and the blocked flap, each with inboard span extension, are presented in figure 10. The effect on the double slotted flap (figs. 5(a), 10, and 11) and the blocked flap (figs. 6, 10, and 11) was a general reduction in lift over the angle-of-attack range. Observation of tufts indicated that the flow over the flap extension was very rough for both flap conditions. Also, in the case of the double slotted flap, the inboard flap extension increased the spanwise flow on the lower surface of the wing. This disturbed flow, which was possibly further disturbed by the inboard flap-support bracket, entered the slots and caused unsteady flow over the vane and flap and consequently a loss in lift.

Tests of the blocked flap were also made with the fuselage replaced by a large plate (fig. 3) which could be translated in a spanwise direction. The results of these tests (see fig. 12) are cross-plotted for various angles of attack in figure 13 to show the variation of lift coefficient with the ratio of plate distance from the plane of symmetry to fuselage radius, d/R. Fuselage-off and fuselage-on test results are plotted at 0 and $1.0d/R$, respectively. The plate began to influence the wing lift at $d/R = 0.7$. Further outboard movement of the plate generally decreased the lift for a given angle of attack and at the maximum d/R tested, 0.93, the plate caused a somewhat greater loss in lift than was caused by adding the fuselage. Observation of the flow with a tuft indicated that when the fuselage was on or the plate was located near the flap ($d/R > 0.8$) there was no vortex, as had been the case for the wing alone, to hold the flow over the flap and therefore the lift was reduced.

Pitching-Moment Characteristics

Pitching-moment characteristics for the wing-fuselage model, with $\delta_f = 0^\circ$, (fig. 7) indicated an increasingly stable variation of pitching moment with lift coefficient to $C_L = 0.7$, where it became unstable. Comparison with the plain-wing results indicates generally similar pitching-moment characteristics except that the addition of the fuselage to the plain wing caused about a 1-percent forward shift in the aerodynamic center to $0.27\bar{c}$, measured at $C_L = 0$. Deflection of the double slotted flap with the fuselage on had much the same effects on the pitching-moment characteristics as were given in reference 1 for the wing. As shown in figure 5(a), the addition of the double slotted flap $(0.500c_f$ vane$)$ resulted in small shifts of the aerodynamic center, a delay in the unstable break of the pitching-moment curve to $C_L \approx 1.0$, and, for example, at $\delta_f = 50.7^\circ$, a $C_{m,W}$ increment of about -0.15. Similar results are shown for the flap and $0.266c_f$ vane (fig. 5(b)) and for the blocked flap (fig. 6).

Drag Characteristics

The addition of the fuselage to the plain wing resulted in an increase in minimum drag coefficient from 0.008 to 0.015. (See fig. 7.)

Comparison of the drag results of figure 5 with the results of reference 1 indicated that the fuselage had a favorable effect on the maximum L/D ratio for a given lift coefficient. At a lift coefficient of 1.1, adding the fuselage increased the L/D values from 3.9 to 4.6 for the flap and large vane and from 3.8 to 4.0 for the flap and small vane.

Effect of Reynolds Number

The results of tests of the double slotted flaps over a range of Reynolds numbers from 0.93×10^6 to 3.35×10^6 are given in figure 14.

The flap deflection for these tests was about 60°. A plot of ΔC_L against Reynolds number is given in figure 15. These results indicate that the lift and pitching-moment characteristics of the double slotted flaps were only slightly affected by the variation of Reynolds number. Some increase in maximum C_L with Reynolds number and a corresponding delay of the unstable break in $C_{m,w}$ to higher values of C_L are shown. No correction was made to account for the change in the angle of zero lift of the wing with $\delta_f = 0^\circ$ shown in figure 14. This effect is attributed to tunnel characteristics. A definite reduction in the drag is shown for lift coefficients in the range just below the stall. At a lift coefficient of 1.0, the lift-drag ratio for the flap and either vane increased from about 4.5 to 5.2 when the Reynolds number was increased.

CONCLUDING REMARKS

A low-speed investigation has been made to determine the effect of a fuselage on the longitudinal aerodynamic characteristics of a 45° swept-back wing equipped with 0.35-semispan double slotted flaps. Comparison is made with previously reported results on the wing alone to determine fuselage effects.

The fuselage had a favorable effect on the lift characteristics of the double slotted flap. However, the presence of the fuselage had an adverse effect on the lift characteristics of an extended plain flap.

The double slotted flaps increased the lift with an increase in flap deflection up to a flap deflection of 80.4° for a flap which had a ratio of vane chord to flap chord of 0.500, and up to 60.8° for the flap with a smaller vane. At these deflections and at an angle of attack of 0°, a lift-coefficient increment of 0.73 was produced by the flap and large vane and a lift-coefficient increment of 0.59 by the flap and small vane. Maximum lift coefficient for the configuration was 1.23 obtained with the flap and large vane at an angle of attack of about 11°, and 1.14 for the flap and small vane at an angle of attack of about 12°.

The fuselage had a favorable effect on the drag characteristics of the double slotted flap at high lift coefficients and had little effect on the pitching-moment characteristics.

For the double slotted flaps deflected about 60°, increasing Reynolds numbers from 0.93×10^6 to 3.35×10^6 had no appreciable effect on the lift characteristics. At moderate lift coefficients, increase in Reynolds number had some slight favorable effects on the drag and pitch characteristics.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 15, 1956.

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TABLE I

COORDINATES OF THE SYMMETRICAL WING AT

SPANWISE STATIONS 1 AND 2

[Coordinates in percent wing chord]

Station 1 [Chord, 20.613 in.]		Station 2 [Chord, 15.771 in.]	
Station	Ordinate	Station	Ordinate
0	0	0	0
.44	.82	.45	.84
.66	.99	.68	1.01
1.11	1.23	1.13	1.26
2.22	1.67	2.27	1.71
4.44	2.32	4.53	2.37
6.66	2.84	6.80	2.90
8.89	3.26	9.08	3.33
13.34	3.93	13.62	4.01
17.80	4.45	18.18	4.54
22.27	4.84	22.74	4.95
26.75	5.12	27.30	5.23
31.22	5.30	31.87	5.42
35.71	5.38	36.46	5.50
40.20	5.34	41.04	5.45
44.70	5.18	45.63	5.28
49.20	4.87	50.23	4.97
60.30	3.81	63.20	3.92
68.92	2.77	70.51	3.11
[a]74.07	2.12	[a]74.52	2.60
80.87	1.59	81.21	1.95
87.66	1.06	87.89	1.29
94.45	.53	94.57	.63
100.00	.10	100.00	.10

[a]Straight line to trailing edge.

TABLE II

COORDINATES OF THE FLAP ENDS

[All values in percent flap chord]

Station	Inboard ordinate		Station	Outboard ordinate	
	Upper surface	Lower surface		Upper surface	Lower surface
0	-5.43	5.43	0	-6.99	6.99
1.45	-2.83	6.81	1.88	-3.82	8.62
2.79	-1.65	7.31	3.42	-2.48	9.12
5.47	0	7.46	6.49	-.59	9.27
8.08	1.11	7.42	9.62	.84	9.17
10.72	2.10	7.39	12.69	2.03	9.02
15.96	3.75	6.97	18.74	4.11	8.38
21.16	4.75	6.58	24.83	5.40	7.78
31.69	5.66	5.78	36.98	6.39	6.59
42.10	4.98	4.94	49.12	5.40	5.35
52.16	4.17	4.17	53.09	5.06	5.06
78.55	2.09	2.09	79.08	2.48	2.48
100.00	.38	.38	100.00	.40	.40

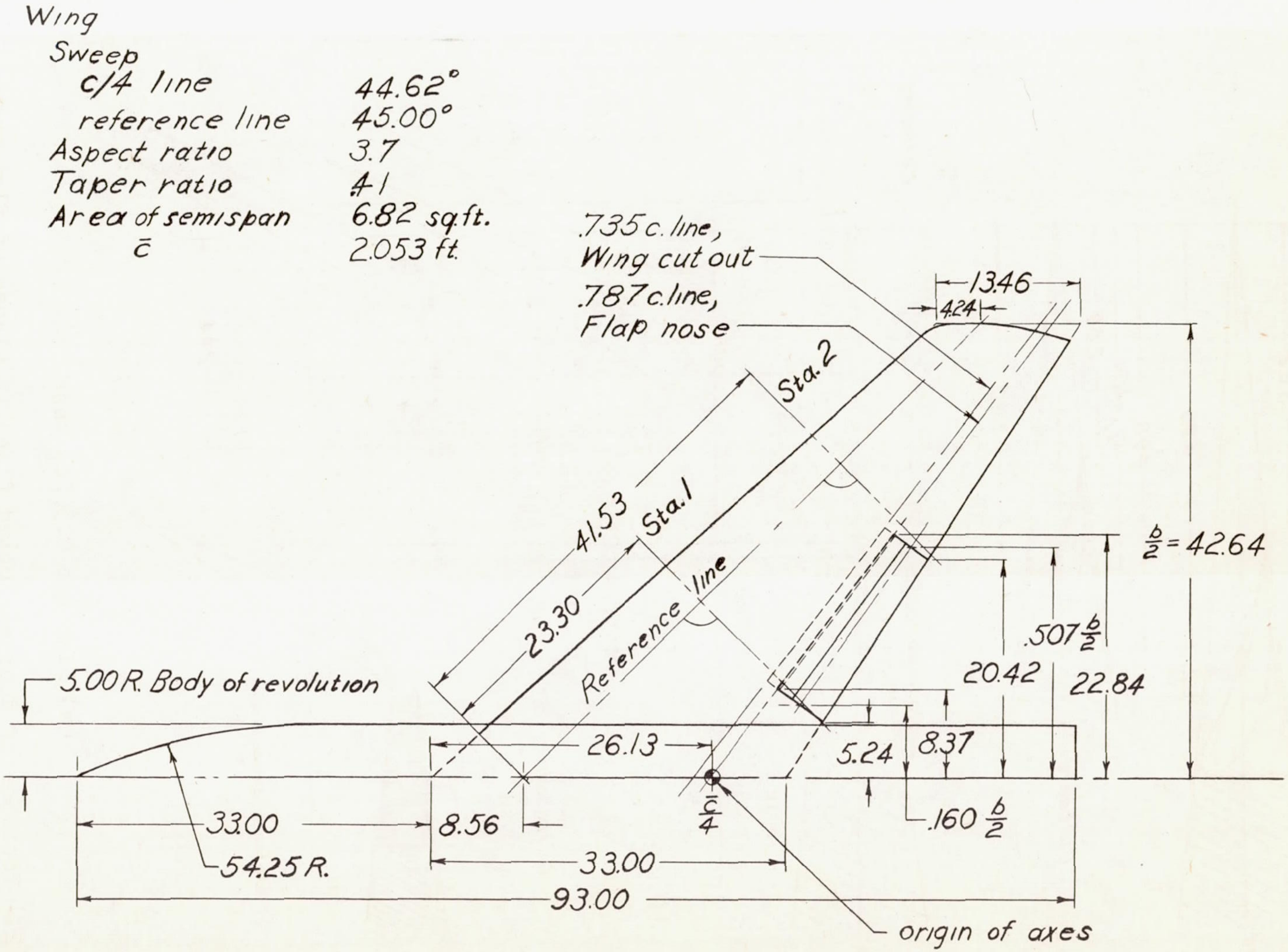
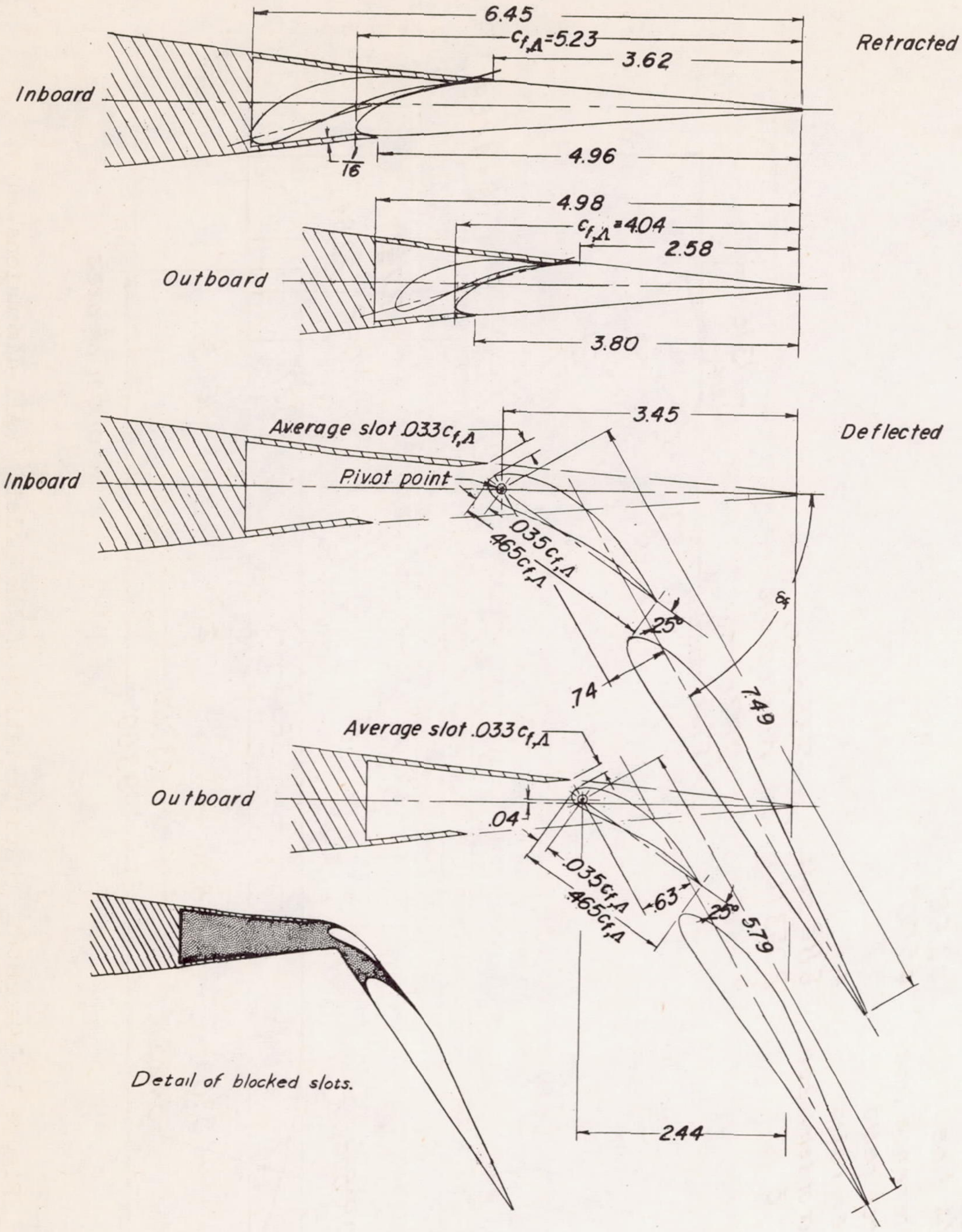
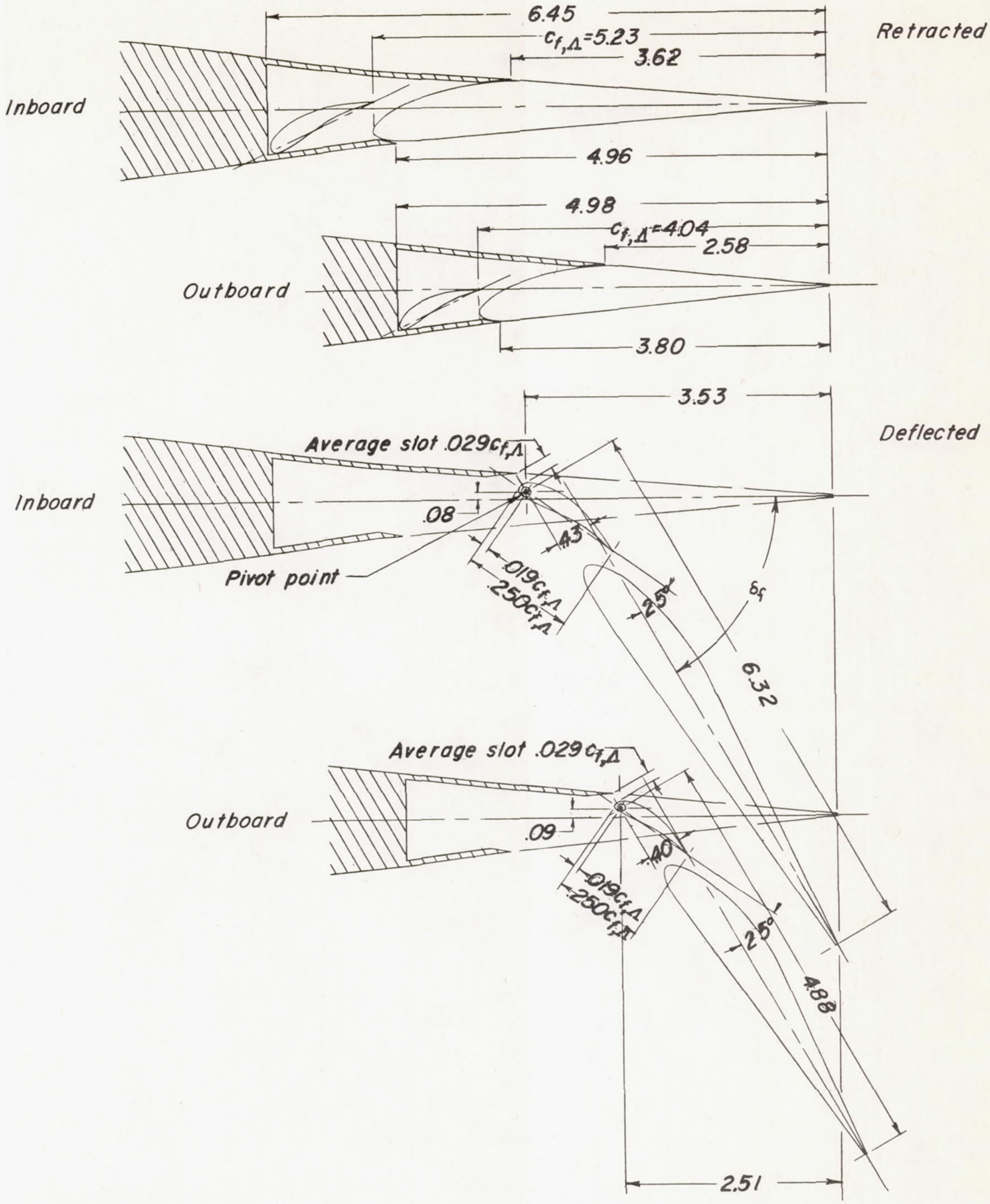


Figure 1.- Geometric characteristics of the model. (All dimensions in inches except as noted.)



(a) Flap and 0.500c_f vane.

Figure 2.- Sections of double slotted flaps in planes of flap ends. (Dimensions are given in inches except when noted.)



(b) Flap and 0.266c_f vane.

Figure 2.- Concluded.

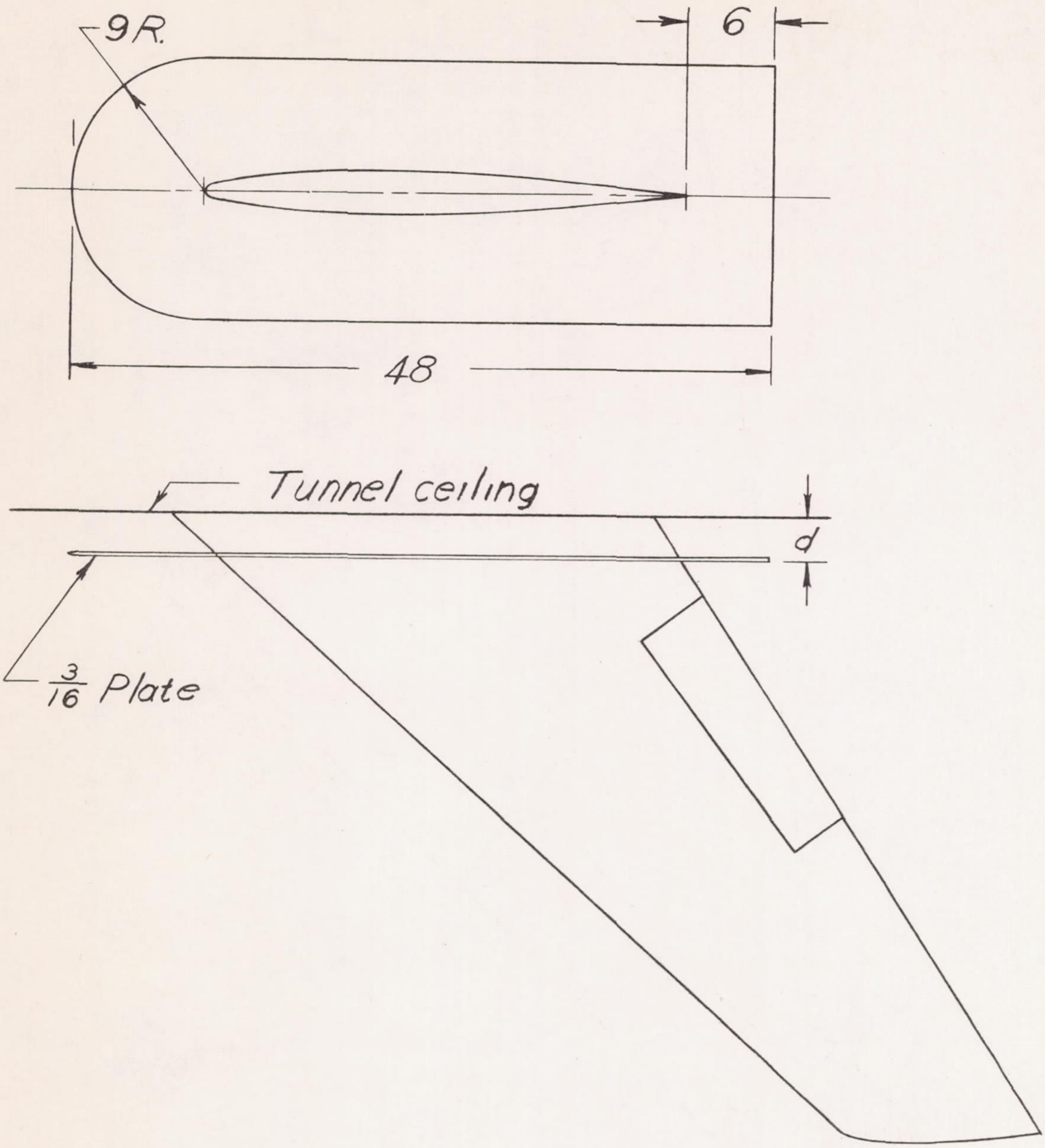


Figure 3.- Detail of fuselage simulation plate. (All dimensions are in inches.)

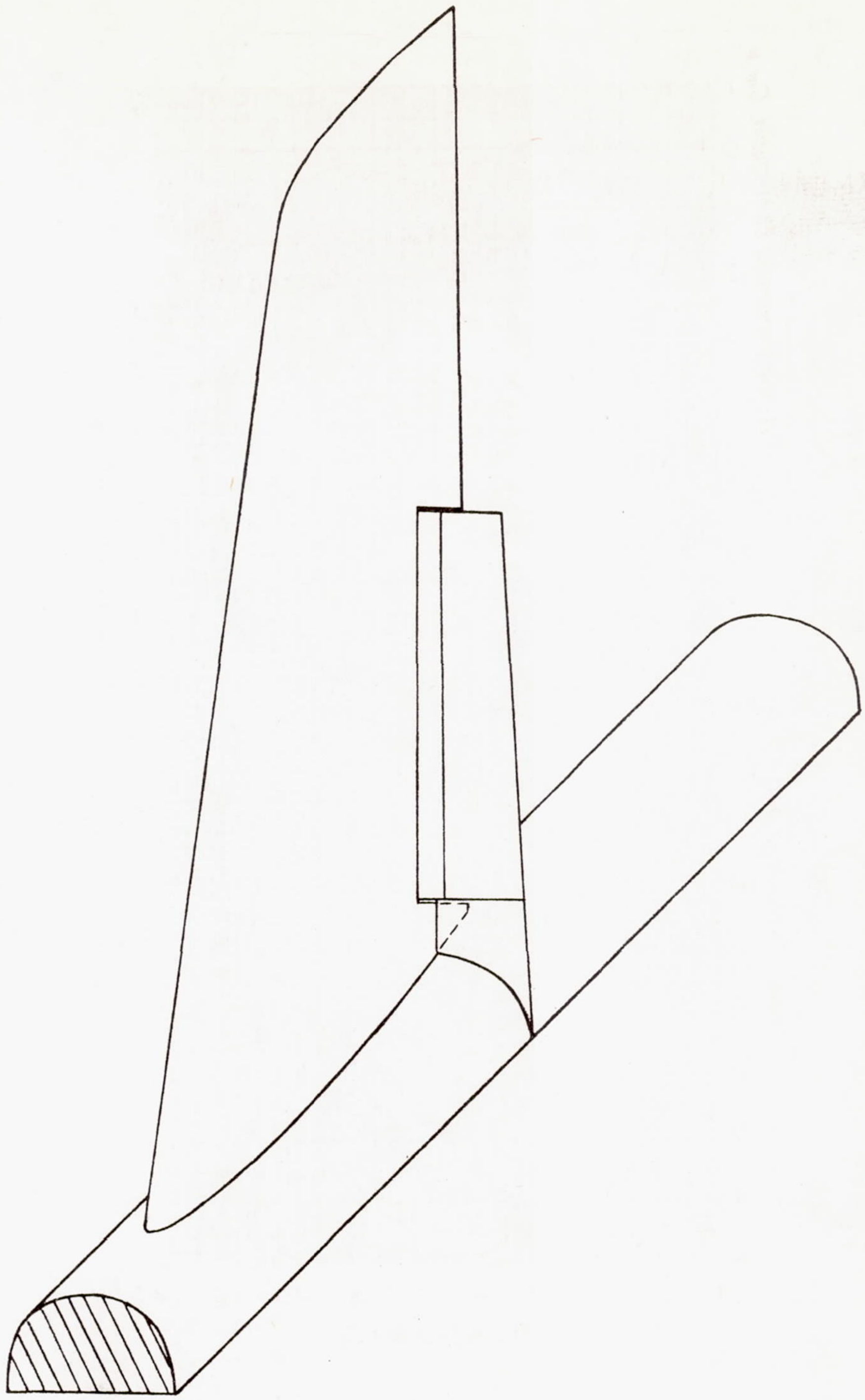
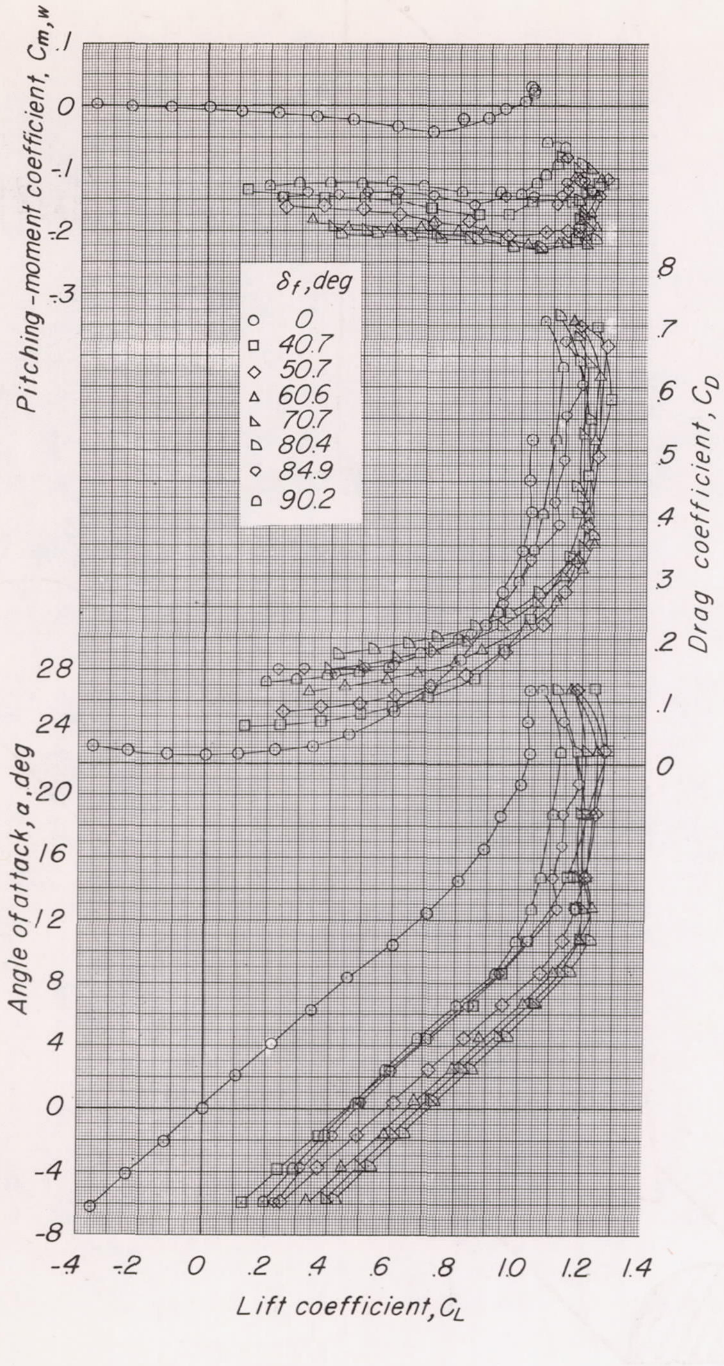
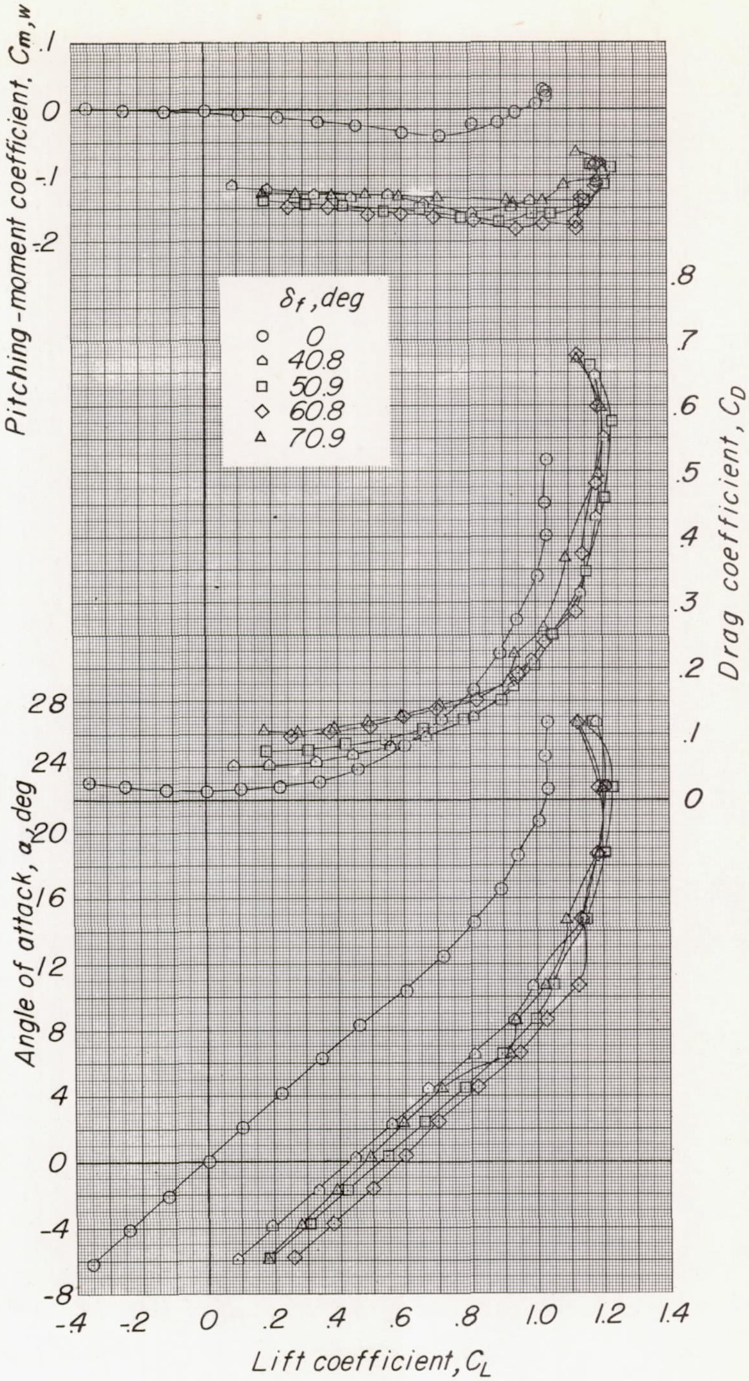


Figure 4.- Flap with span extended to the fuselage.



(a) $0.500c_f$ vane.

Figure 5.- Effect of deflection of the double slotted flaps on the aerodynamic characteristics of the wing-fuselage model in pitch.



(b) $0.266c_f$ vane.

Figure 5.- Concluded.

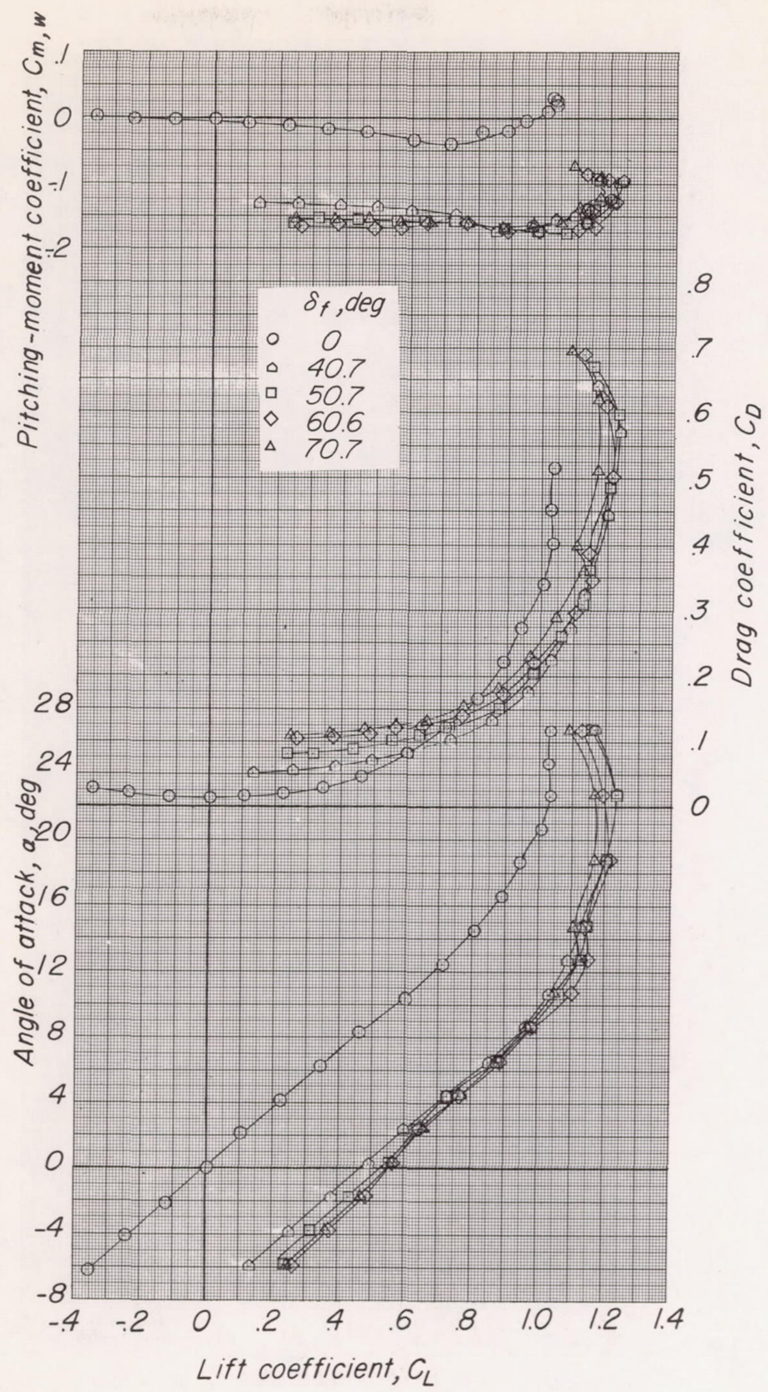


Figure 6.- Effect of deflection of the blocked flaps on the aerodynamic characteristics of the wing-fuselage model in pitch. Flap with $0.500c_f$ vane.

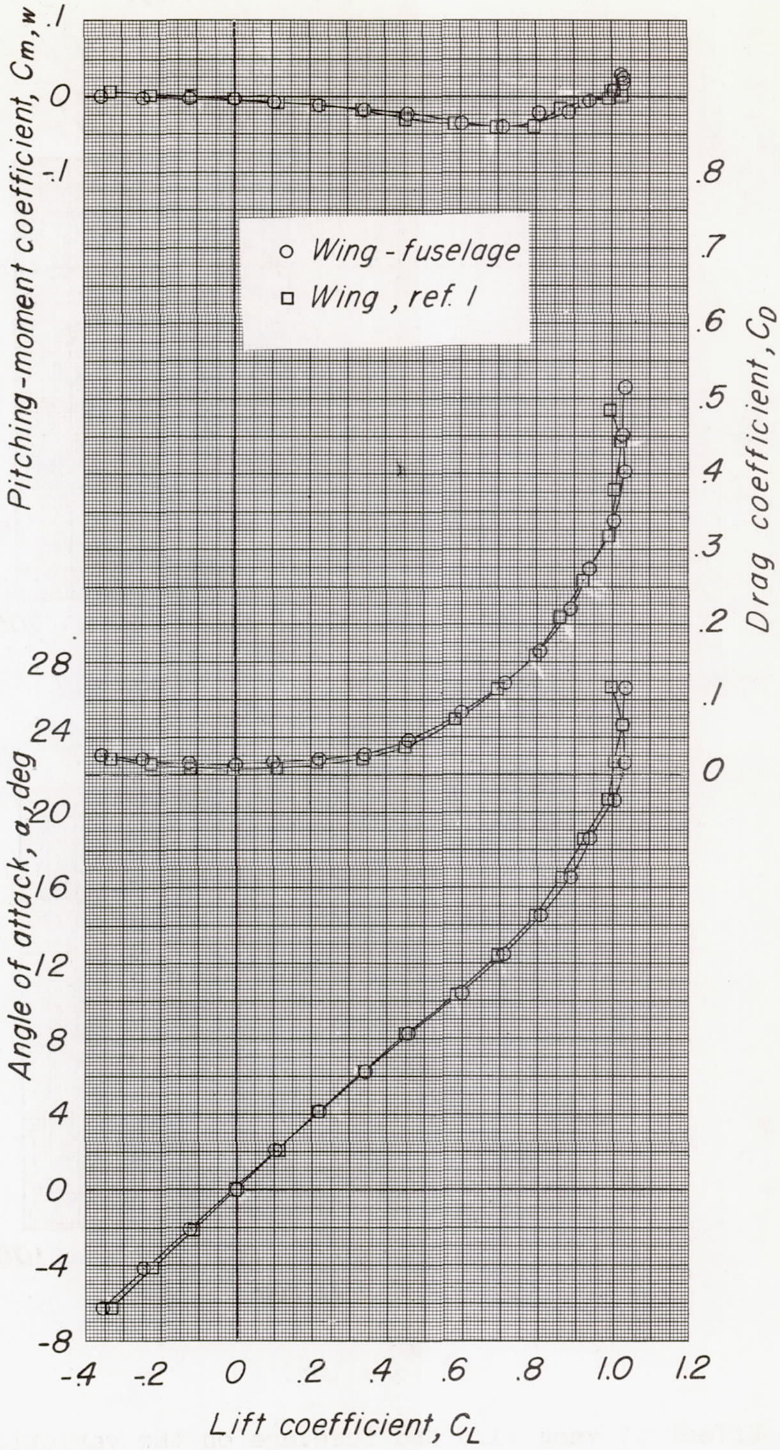
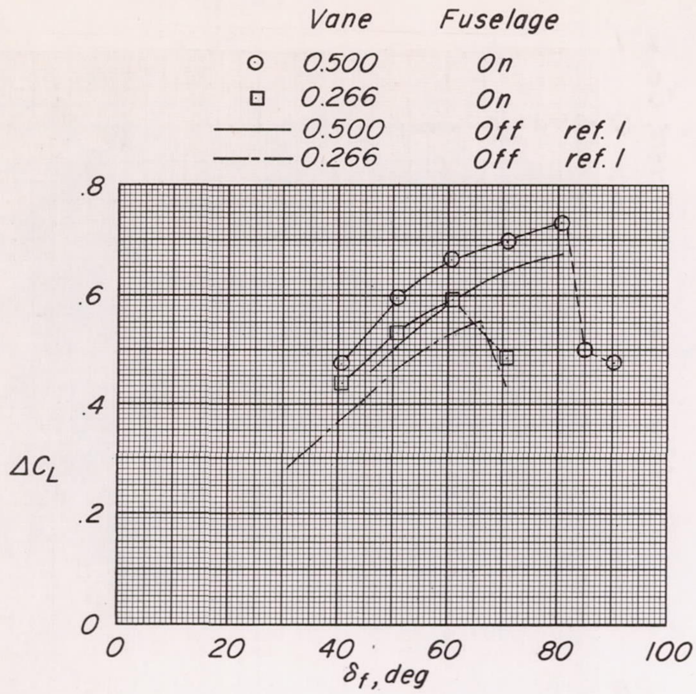
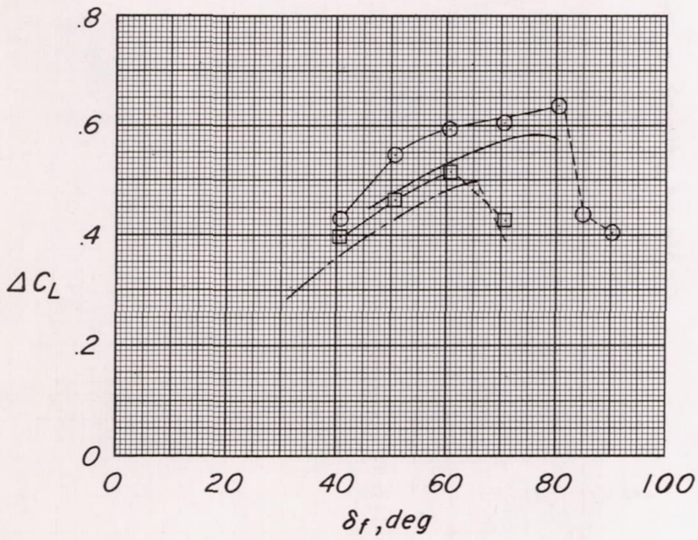


Figure 7.- Effect of fuselage on the aerodynamic characteristics of the plain wing in pitch. $\delta_f = 0^{\circ}$.

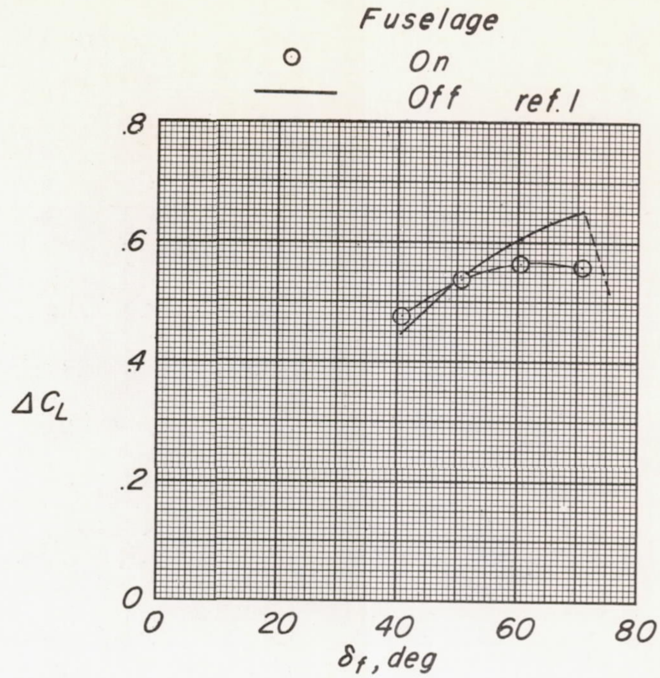


(a) $\alpha = 0^{\circ}$.

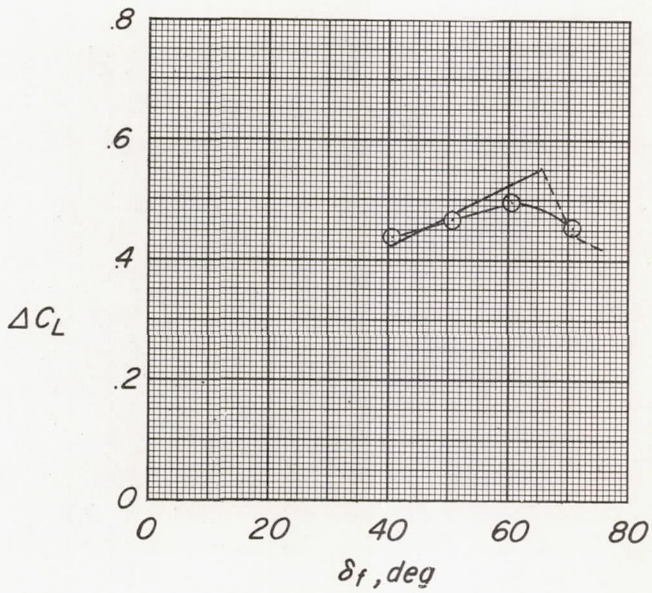


(b) $\alpha = 10^{\circ}$.

Figure 8.- Effect of vane size and fuselage on the variation of lift-coefficient increment with flap deflection. Double slotted flaps.



(a) $\alpha = 0^{\circ}$.



(b) $\alpha = 10^{\circ}$.

Figure 9.- Effect of the fuselage on the variation of lift-coefficient increment with deflection of the blocked flap. Flap with $0.500c_f$ vane.

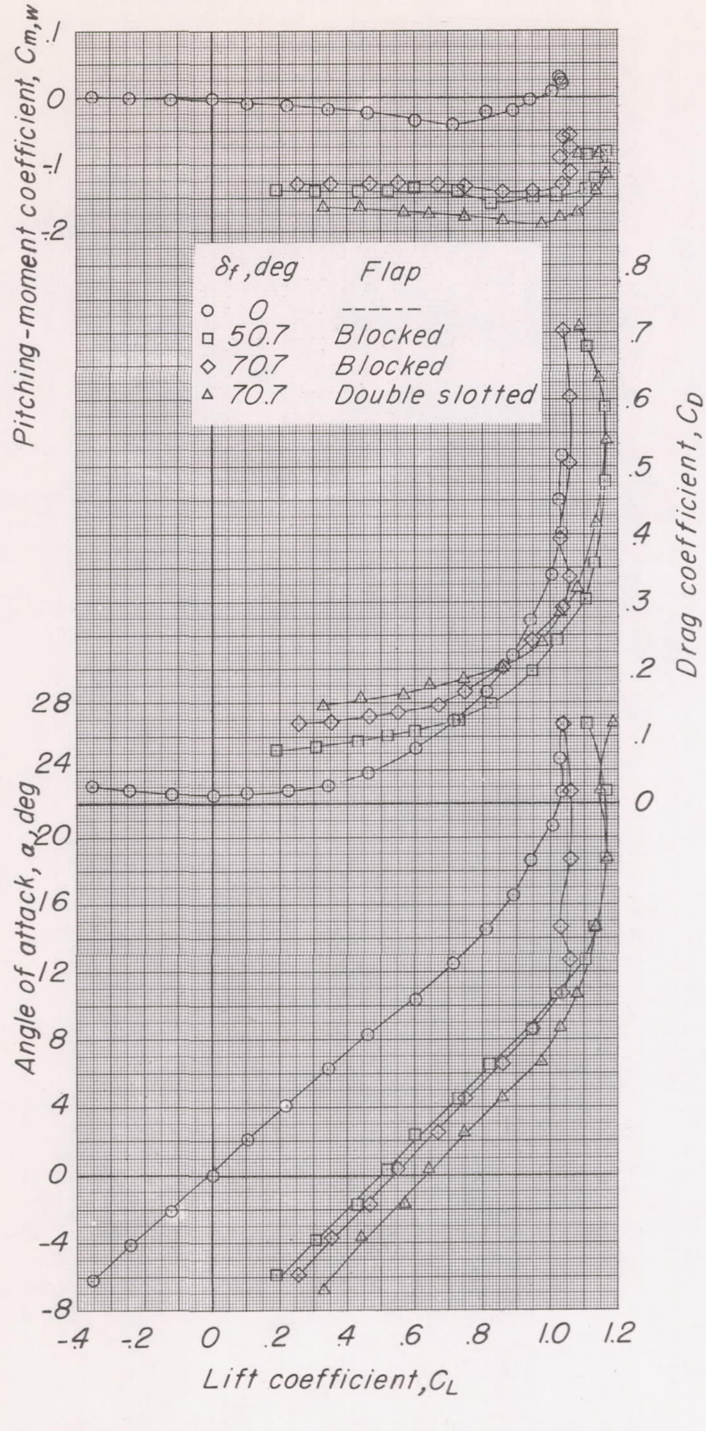
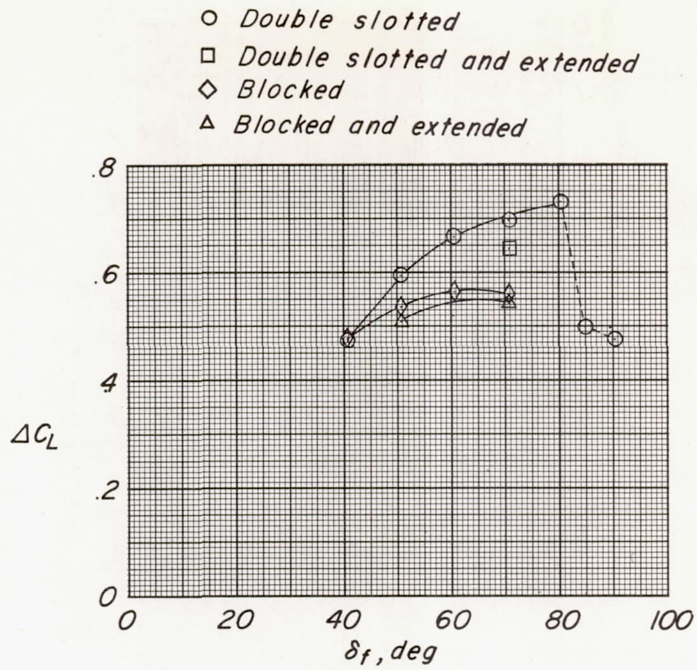
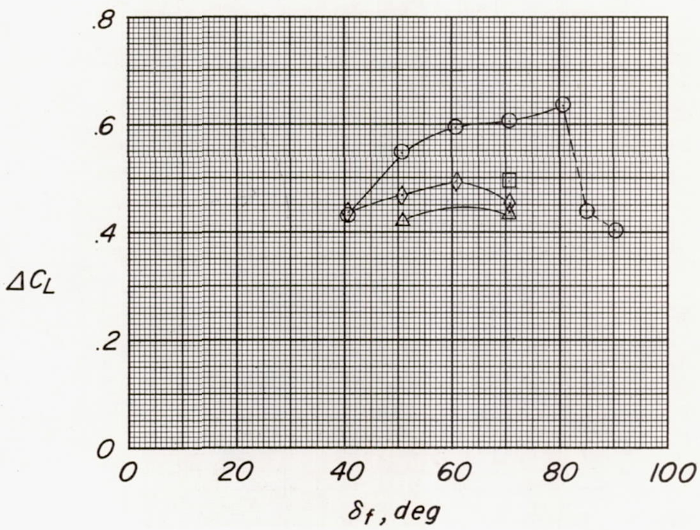


Figure 10.- Effect of spanwise extension of the flap inboard to the fuselage on the aerodynamic characteristics of the wing-fuselage combination in pitch. (Flap with $0.500c_f$ vane.)



(a) $\alpha = 0^{\circ}$.



(b) $\alpha = 10^{\circ}$.

Figure 11.- Effect of blocking the slots or extending the flap to the fuselage on the variation of lift-coefficient increment with deflection of the double slotted flap and $0.500c_f$ vane.

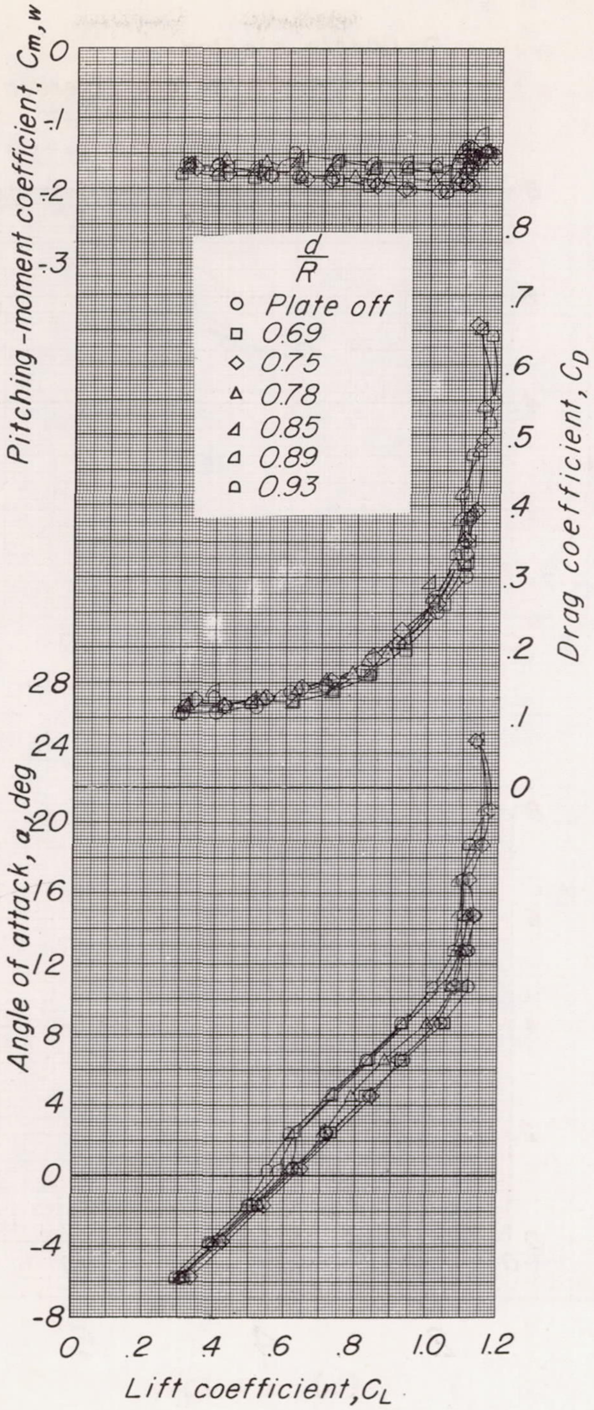


Figure 12.- Effect of fuselage simulation plate location on the aerodynamic characteristics in pitch of the blocked flap. Flap with $0.500c_f$ vane; $\delta_f = 60.05^\circ$.

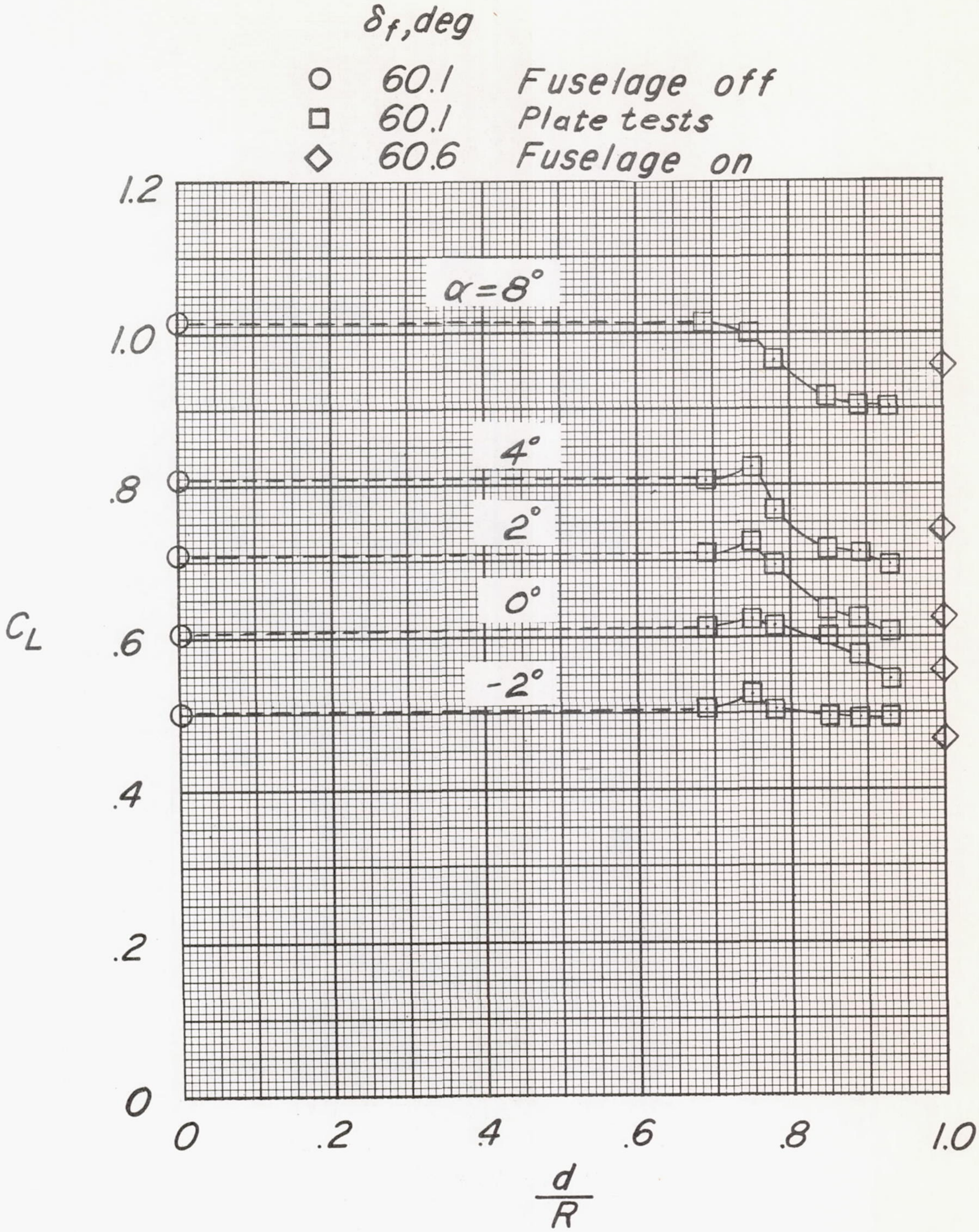
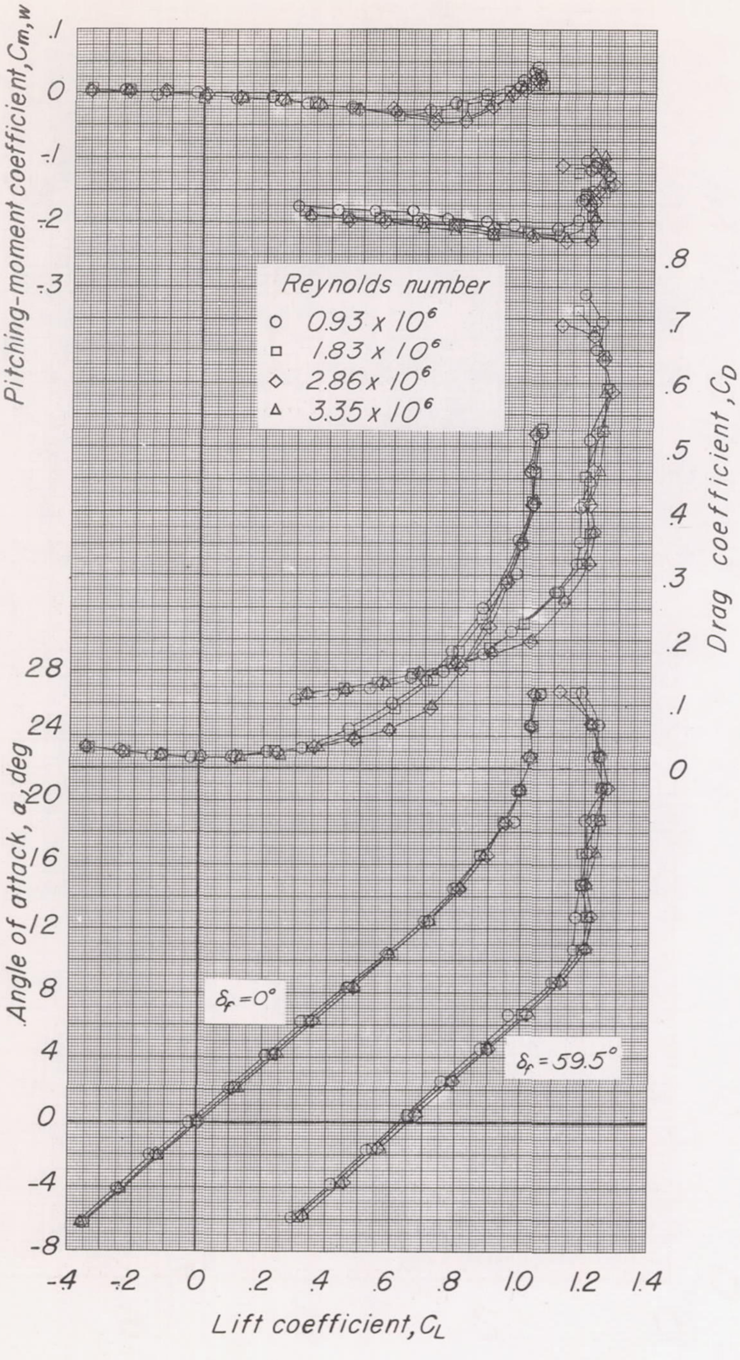
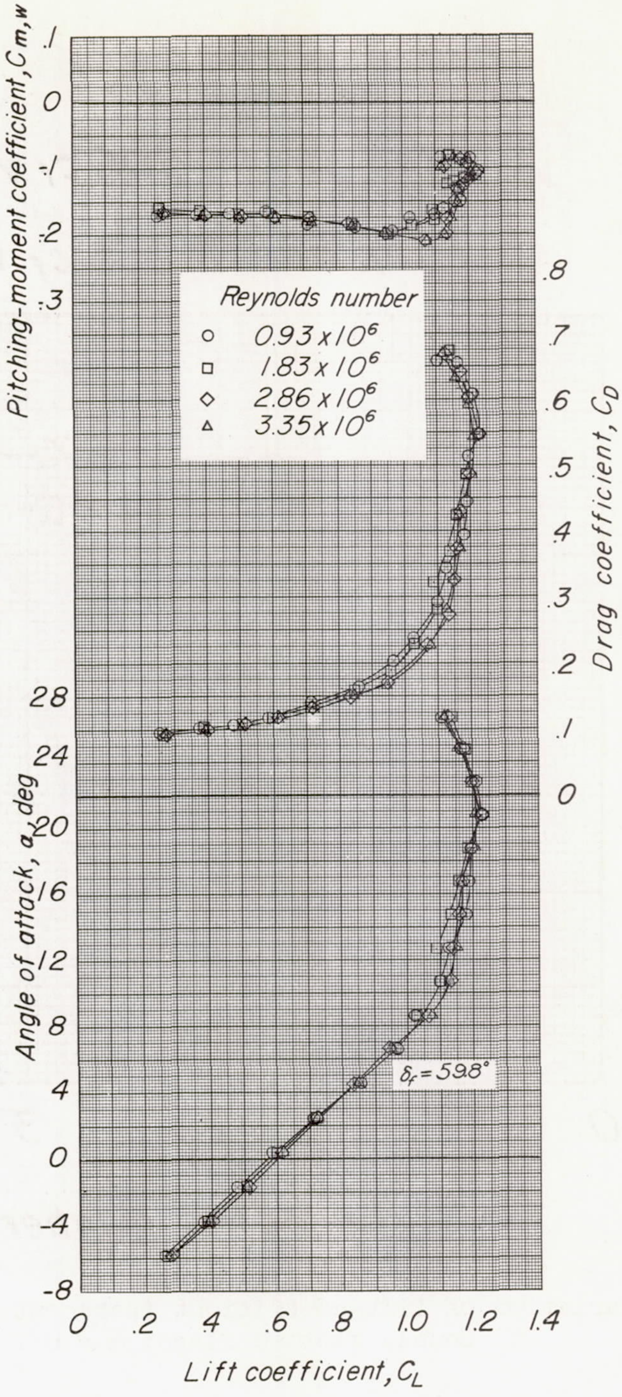


Figure 13.- Variation of lift coefficient with fuselage simulation plate location. Blocked flap with $0.500c_f$ vane.



(a) Flap and $0.500c_f$ vane.

Figure 14.- Effect of Reynolds number on the aerodynamic characteristics in pitch of the double slotted flaps.



(b) Flap and $0.266c_f$ vane.

Figure 14.- Concluded.

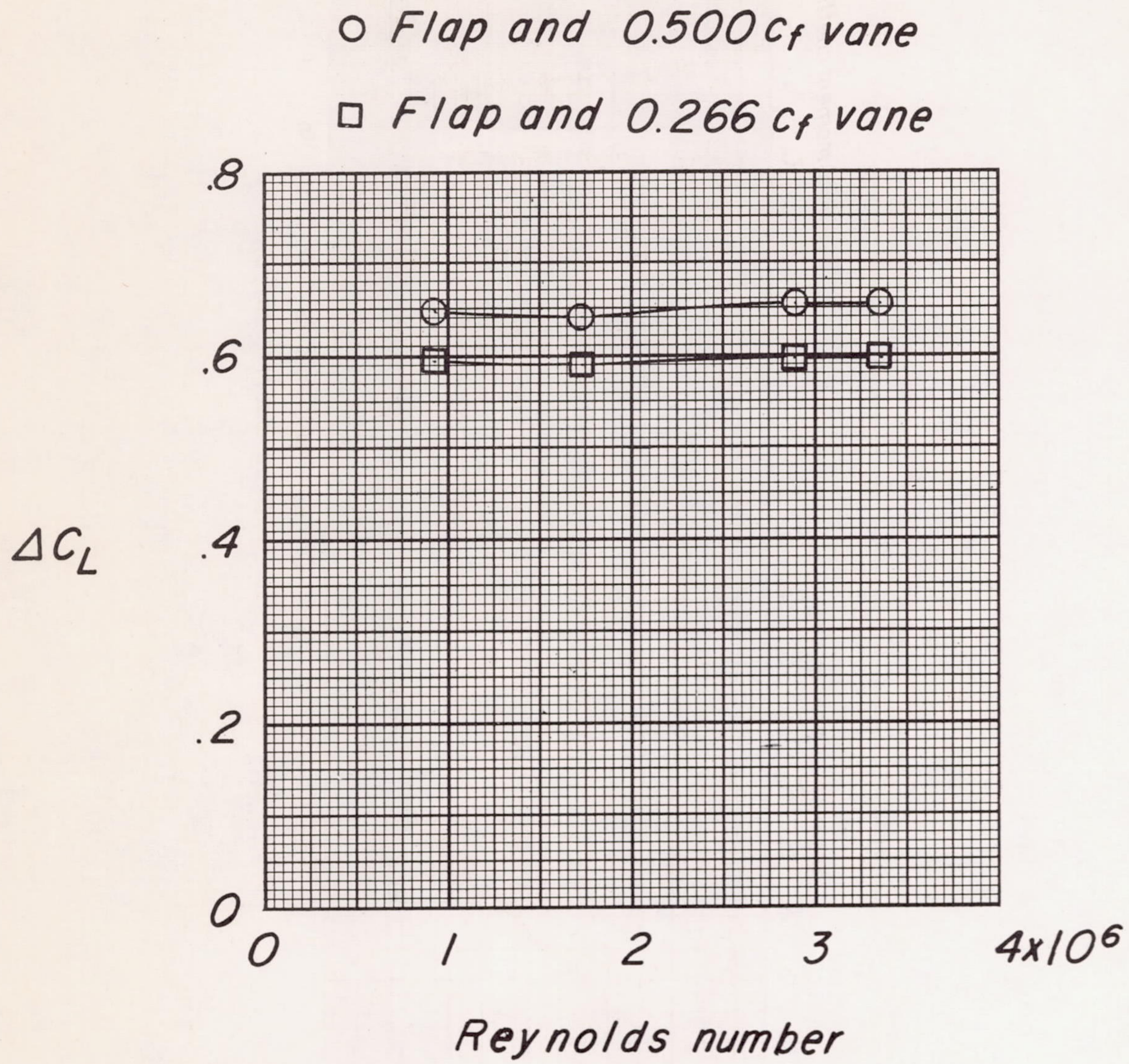


Figure 15.- Variation of lift-coefficient increment with Reynolds number. Double slotted flaps; $\alpha = 0^{\circ}$.

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